Three-Year Retrospective Study of Complications Arising during Interventional Procedures

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Summary

This retrospective study aimed to assess the percentage of complications arising in our daily practice of interventional procedures, comparing our findings with those of leading international reference centers and accepted guidelines for endovascular treatment. During the three-year period considered (2000-2002), we performed 246 interventional procedures, divided into seven different pathological conditions: aneurysms, brain AVMs dural and carotid cavernous fistulae, spine-spinal cord tumours, head-neck tumours, carotid stenosis and thrombolysis.

Aneurysmal disease accounted for 45% of all endovascular procedures.

In conclusion, four periprocedural complications arose in the course of 246 procedures resulting in one death and three cases of permanent neurological deficit (2%).

Introduction

Recent years have seen a major increase in neuroradiological endovascular procedures spreading from leading institutions to virtually all neuroradiology departments. As endovascular treatment has become an established standardized procedure, a need has arisen for retrospective analysis of the incidence of periprocedural complications, their causes and their management and the final clinical outcome of interventional procedures [21,22,23].

We undertook a three-year survey of endovascular procedures carried out from 2000 to 2002 to obtain objective evidence of results in relation to safety guarantees offered to patients in performing endovascular procedures at our neuroradiology service [6,9,17];

Moreover, we wish to compare our findings with the case series of leading international reference centers and accepted guidelines for endovascular procedures [1,3,4,10,14-16,18-20,24-28].

Material and Methods

During the period considered, 246 endovascular procedures were performed for seven groups of diseases:

1) Aneurysms: 110 embolization sessions in 96 patients (61F, 35M)

2) Brain AVMs 34 embolization sessions in 20 patients (9F, 11M)

3) Dural (9) and Carotid-Cavernous (12) Fistulae: 21 embolization sessions in 18 patients (10F, 8M)

4) Spine-spinal cord tumours: 42 embolization sessions in 40 patients (12F, 28M)

5) Head-neck tumours: 17 embolization sessions in 15 patients (7F, 8M)

6) Carotid stenosis: 19 sessions positioning stents in 18 patients (7F, 11M)

7) Thrombolysis: 1 session in one patient F.

DISEASE	
Embolized Brain Aneurysms	94
Attempts to Embolize Brain Aneurysms	16
Embolized Brain AVMs	29
Embolized Fistulae	21
Attempts to Embolize Brain AVM or Fistulae	6
Spine-Spinal Cord Tumours	42
Head-Neck Tumours	17
Unsuccessful Embolization of Head-Neck Tumours	1
Carotid Stenosis	19
Thrombolysis	1
TOTAL	246

Complications arising during or after treatment, occurring within 30 days after the interventional procedure, were divided as follows:

1. Technical complications not resulting in permanent neurological deficit,
2. Clinical complications not resulting in permanent neurological deficit,
3. Clinical complications resulting in permanent neurological deficit.

Results

GROUP 1 – Aneurysms

Aneurysmal disease accounted for 45% of endovascular procedures. Over the three-year period we performed 110 sessions: 94 were successful whereas embolization failed in 16.

The complications arising during and after embolization are presented in tables 1 to 3:

- C.L.: patient with a large wide-necked aneurysm of the right carotid siphon. During placement of the second coil, the first was displaced and a loop migrated into the siphon. There were no circulation changes so the coil was left. Two years later, the patient is still receiving anti-aggregating therapy and the position of the coil remains unchanged (could the drug treatment be suspended?).
- P.L.: patient with a wide-necked aneurysm of the right carotid siphon who showed a good compensation by the controlateral circulation at carotid occlusion test. Treatment was planned with first choice embolization packing the lesion with coils and second choice occlusion of the carotid artery. During the procedure, the coils could not be maintained within the aneurysmal sac so we decided to occlude the carotid siphon. The patient has no permanent neurological deficit.

	SESSIONS	**PATIENTS**	**FEMALES**	**MALES**	**AVERAGE AGE**
Embolized Brain Aneurysms	94	80	51	29	58
Attempted Embolization of Brain Aneurysms	16	14	10	4	66
Embolized Brain AVMs	29	16	9	7	38
Embolized Fistulae	21	17	9	8	51
Attempted Embolization of Brain AVM or Fistulae	6	5	1	4	39
Spine-Spinal Cord Tumours	42	40	12	28	46
Head-Neck Tumours	17	15	7	8	44
Failure to Embolize Head-Neck Tumours	1	1	1	0	71
Carotid Stenoses	18	17	6	11	68
Carotid Stenoses and Placement Failure	1	1	1	0	68
Thrombolysis	1	1	1	0	64
TOTAL	246	207	108	101	55,7

Table 1 **Technical complications without permanent neurological deficit**

Year	Patients	Age	M/F	Clinical Onset	N° Sessions	% Closure	Complication
2000	C.L.	69	F	Chance finding	1	80%	Coil loop in siphon
2001	P.L.	42	F	Chance finding	1	Carotid Occlusion	Migration of coils into vessel
2001	V.T.	56	F	Chance finding	4	80%	Stent migrated into popliteal artery
2002	R.D.	56	F	Chance finding	2	100%	Coil loop protruding into vessel

Table 2 **Technical complications without permanent neurological deficit**

Year	Patients	Age	M/F	Clinical Onset	N° Sessions	% Closure	Complication
2000	F.G.	45	M	SAH	1	100%	rupture of aneurysmal sac
2001	F.M.	50	F	Chance Finding	1	100%	rupture of aneurysmal sac
2001	G.L.	54	F	SAH	2	100%	rupture of aneurysmal sac
2002	B.L.	62	M	Chance Finding	1	100%	A2-A4 occlusion, small ischaemic lesion on CT scan
2002	P.C.	73	f	SAH	1	100%	rupture of aneurysmal sac

- V.T.: patient with a large aneurysm of the carotid siphon already treated by coil embolization but the lesion had recanalized due to coil compaction During the second session, an intracranial stent was positioned but it detached from the support/guiding catheter and migrated spontaneously into the left poplitieal artery. The patient had no sequelae in his lower limb and the aneurysm was again embolized with coils.

- R.D.: patient with a large aneurysm of the carotid siphon who had undergone surgery. Postoperative angiographic follow-up disclosed a residual aneurysm neck with a large opening on the vessel. Good coil compaction was achieved but a coil loop partially protruded into the siphon lumen.

The aneurysmal sac ruptured during coil insertion in four patients. Two cases involved aneurysms of the medial wall of the carotid siphon, in the carotid cava stretch, lesions described by Yasargil as being at high risk of rupture during microneurosurgery (31). Without doubt, the fragility of these aneurysms increases the likelihood of rupture during embolization.

- F.G and F.M. were brother and sister. The brother presented with SAH from an aneurysm of the left A1-A2 angle. During the embolization procedure, the aneurysmal sac ruptured as the second coil was inserted. His sister had a CT angiography scan performed for family screening which disclosed a siphon aneurysm which also ruptured during coil insertion. These two patients belong to a family with a high incidence of aneurysmal disease. A third family member, the second sister, recently underwent CT angiography which disclosed four aneurysms: two were treated surgically and two by embolization.

After reversing heparinization, the embolization procedure was completed in all these patients with the insertion of additional coils until the aneurysmal sac was completely occluded. No patient had permanent neurological deficit.

Table 3 **Clinical complications with permanent neurological deficit**

Year	Patients	Age	M/F	Clinical Onset	N° Sessions	% Closure	Complication	Deficit
2000	D.P.	57	M	Chance Finding	1	100%	A2-A4 thrombosis ischaemic lesion	Right Haemiparesis
2000	M.G.	57	M	SAH	1	100%	LEFT FTP ischaemic lesion	Right Haemiparesis
2001	G.P.	43	F	Chance Finding	1	100%	Pontine ischaemia	Right Haemiparesis

Three patients had permanent neurological deficit.

- D.P.: patient with an aneurysm of the left A1-A2 junction disclosed by chance. The aneurysm was excluded from the circulation by packing with four GDC coils, but opacification of the left A2-A4 portions was no longer visible. The patient subsequently developed cerebral ischaemia resulting in right hemiparesis.
- M.G.: patient presenting with SAH and left frontal haematoma from bleeding of a small aneurysm of the left A1-A2 junction. Final control imaging disclosed complete exclusion of the aneurysm from the circulation without flow abnormalities. CT follow-up on the following day showed a left fronto-temporal-parietal ischaemic lesion. The patient was discharged with right hemiparesis.
- G.P.: patient with a large wide-necked aneurysm of the basilar artery. To keep the coils inside the lesion, an intracranial stent was positioned in the basilar artery to ensure complete coil packing of the aneurysmal sac. Despite anticoagulant and anti-aggregating therapy, stent thrombosis occurred three hours after completion of the procedure resulting in pontine ischaemia. The patient had severe neurological deficits and is currently undergoing rehabilitation.

GROUP 2 Brain AVMs

- C.R.: patient presenting episodes of left-sided facial paraesthesis. CT scan disclosed a large left fronto-parietal brain AVM. He underwent an initial embolization session leading to 40% closure of the lesion. After discharge, eight days after embolization, the patient had a massive haematoma and died. A review of the images acquired during the embolization procedure failed to show changes in the arterial or venous circulation accounting for the haematoma.

GROUP 3
Dural and Carotid - Cavernous Fistulae

- Z.O.: patient with a post-traumatic carotid-cavernous fistula with extensive rupture of the vessel wall resulting in pseudo-aneurysm. After

Table 4 **Complications arised after treatment of a brain AVM**

Year	Patients	Age	M/F	Clinical Onset	N° Emb Sessions	% AVM Closure	Complication	Outcome
2001	C.R.	70	M	Transient focal deficit	1	40%	Haematoma 8 days after embolization	Died

Table 5 **Complications arised after treatment of a carotid-cavernous fistula**

Year	Patients	Age	M/F	Clinical Onset	N° Emb Sessions	Complication	Outcome
2001	Z.O.	70	M	Amaurosis	2	Left post-traumatic ischaemia	died

Table 6 **Total complications observed**

DISEASE	TOTAL	COMPLICATIONS	%
EMBOLIZED BRAIN ANEURYSMS	94	3	3.2%
ATTEMPTED EMBOLIZATION OF BRAIN ANEURYSMS	16	0	
EMBOLIZED BRAIN AVMS	29	1	3.4%
EMBOLIZED FISTULAE	21	1	4.7%
ATTEMPTED EMBOLIZATION OF AVM + FISTULAE	6	0	
SPINE-SPINAL CORD TUMOURS	42	0	
HEAD-NECK TUMOURS	17	0	
FAILURE TO EMBOLIZE HEAD-NECK TUMOURS	1	0	
CAROTID STENOSES	19	0	
THROMBOLYSIS	1	0	
TOTAL	246	5	2%

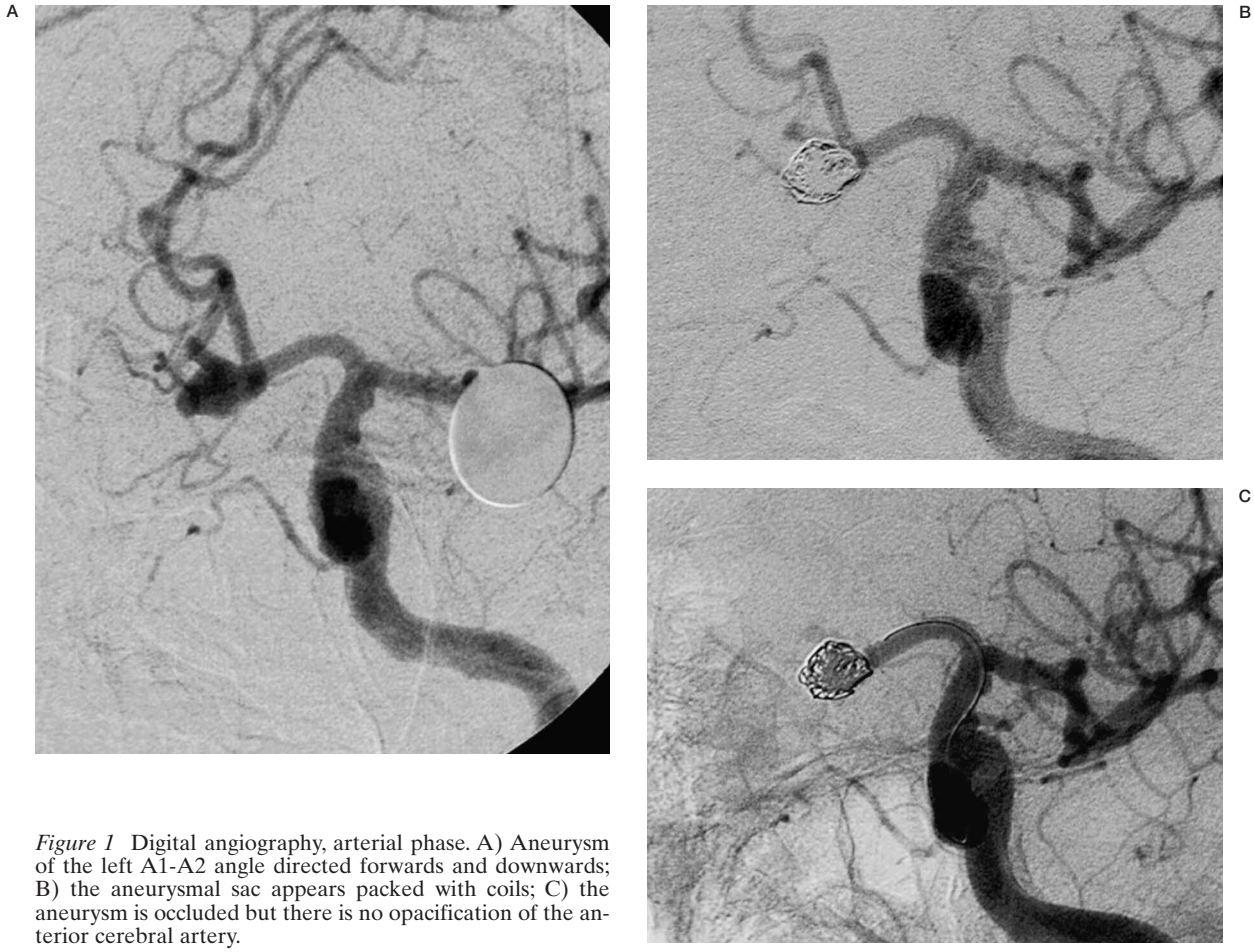

Figure 1 Digital angiography, arterial phase. A) Aneurysm of the left A1-A2 angle directed forwards and downwards; B) the aneurysmal sac appears packed with coils; C) the aneurysm is occluded but there is no opacification of the anterior cerebral artery.

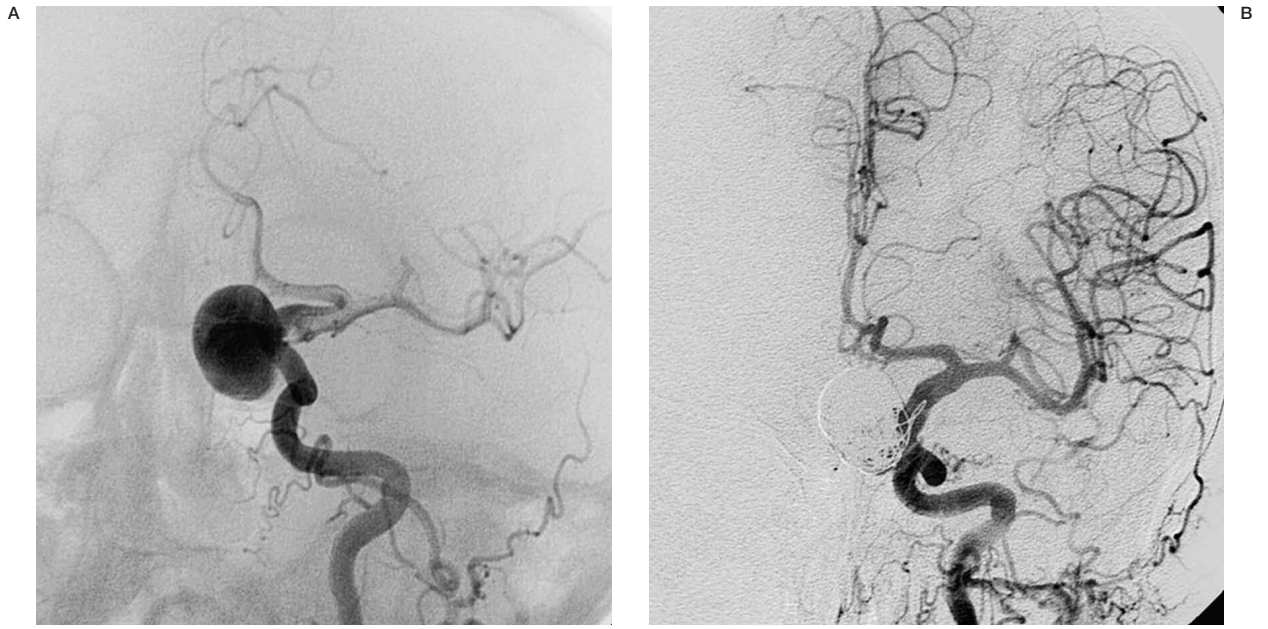

Figure 2 Digital angiography, arterial phase. A) Large wide-necked aneurysm of the left carotid siphon; B) imaging at the end of embolization shows a loop protruding into the siphon.

positive occlusion testing, the patient underwent a first embolization session to occlude the internal carotid artery with detachable balloons. The large opening of the lesion prevented stable balloon placement with complete closure of the fistula. Another two balloons were inserted during a second embolization session a few hours later, but the patient failed to tolerate complete occlusion of the internal carotid artery and subsequently developed severe ischaemia of the hemisphere ipsilateral to the fistula and died.

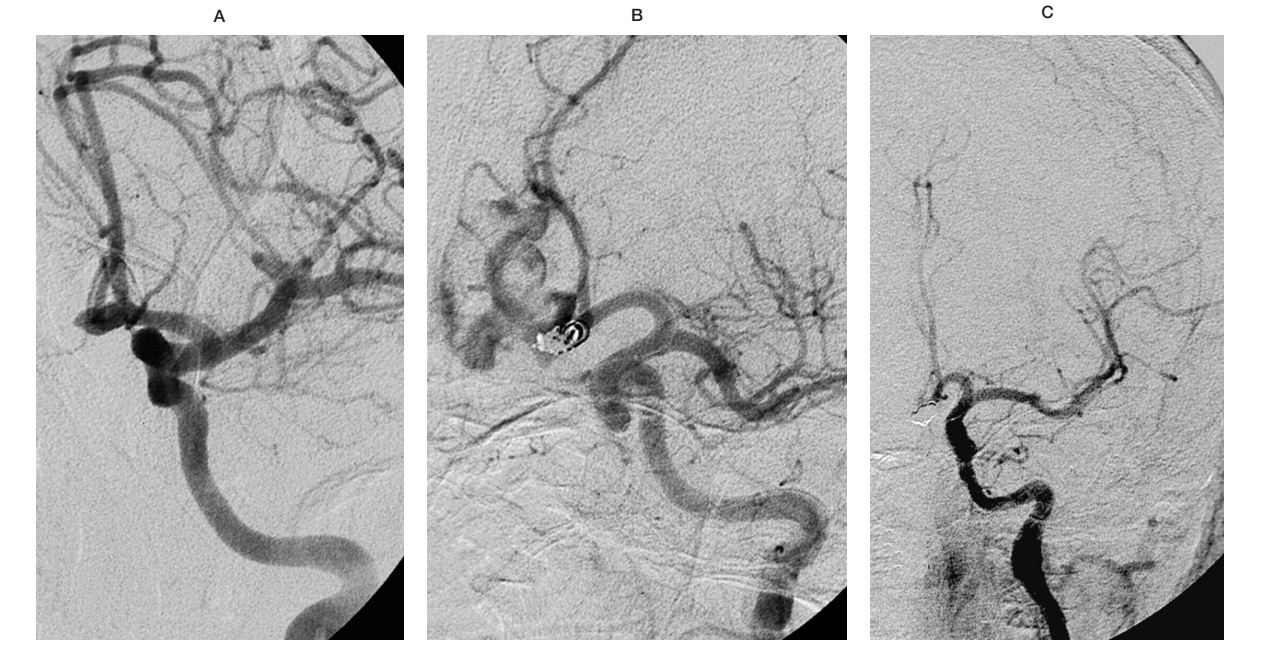

Figure 3 Digital angiography, arterial phase. A) Aneurysm of the left A1-A2 angle; B) after placement of the second coil, contrast medium can be seen leaking into the subarachnoid space adjacent to the sac; C) imaging at the end of embolization shows complete occlusion of the sac.

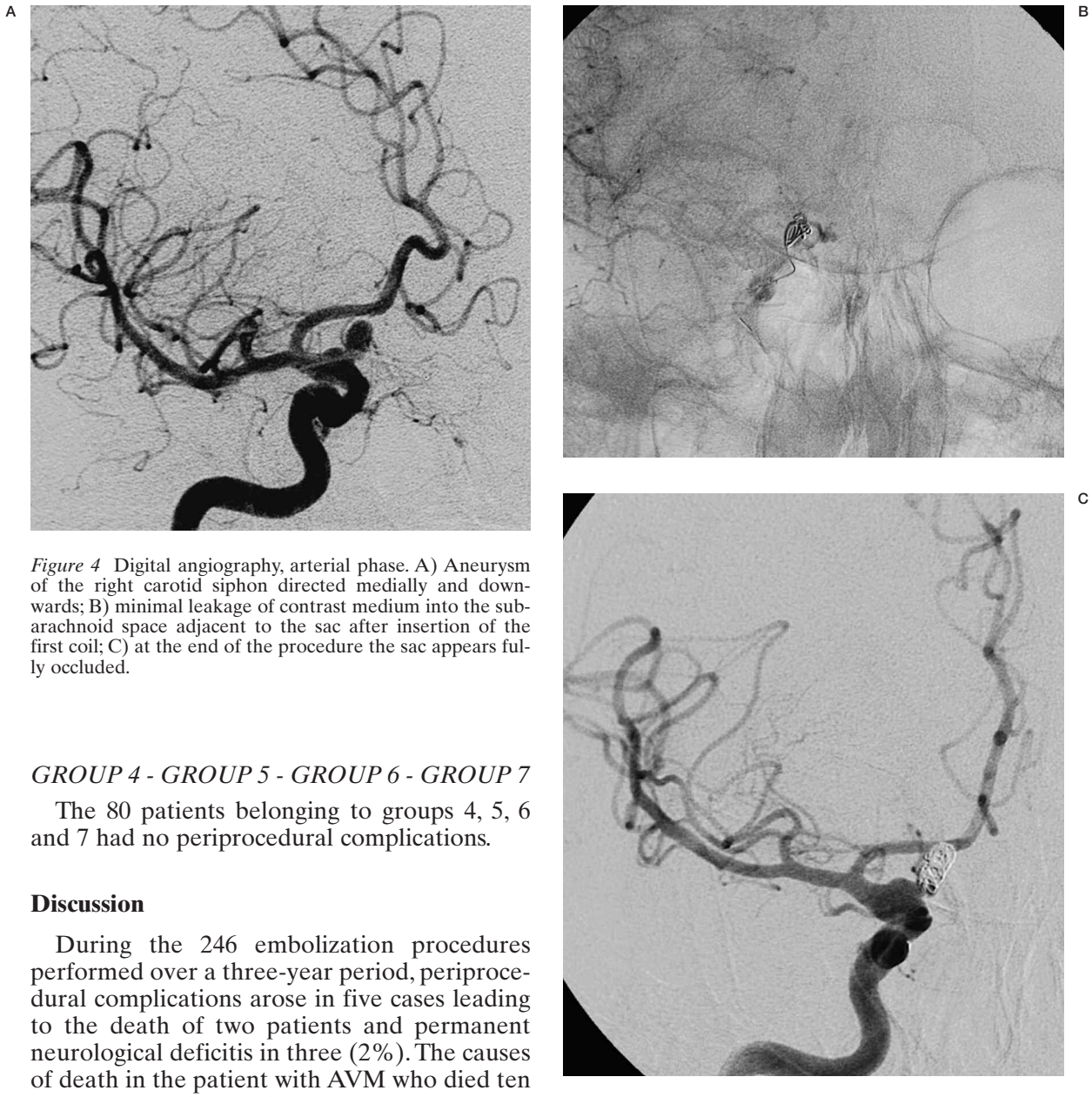

Figure 4 Digital angiography, arterial phase. A) Aneurysm of the right carotid siphon directed medially and downwards; B) minimal leakage of contrast medium into the subarachnoid space adjacent to the sac after insertion of the first coil; C) at the end of the procedure the sac appears fully occluded.

GROUP 4 - GROUP 5 - GROUP 6 - GROUP 7

The 80 patients belonging to groups 4, 5, 6 and 7 had no periprocedural complications.

Discussion

During the 246 embolization procedures performed over a three-year period, periprocedural complications arose in five cases leading to the death of two patients and permanent neurological deficitis in three (2%). The causes of death in the patient with AVM who died ten days after initial partial embolization remain unsettled. Given the pathophysiology of these lesions and the fact that death occurred within 30 days after the procedure, this patient is reported.

The percentage of aneurysm rupture during embolization appears "physiological" in relation to the features of aneurysmal disease and the fact that 80% of the aneurysms is this series were treated in an emergency setting within 24h of haemorrhage [2,5,11,13,29]. Plainly, we must always be prepared for the need to repair ruptured leasions. The damage caused by rupture will depend on the extent of potential haemorrhage, proportional to lesion location, aneurysm size, type of flow in the feeding artery, etc. In our series, rupture was confined to small or very small aneurysms (maximum diameter 8 mm) in familial cases: two of the three cases involved a brother and sister. In addition, two of the lesions arose from the medial wall of the carotid siphon in the carotid cava stretch of the artery deemed to be at high risk of rupture during microneurosurgery [31]. This fragility must

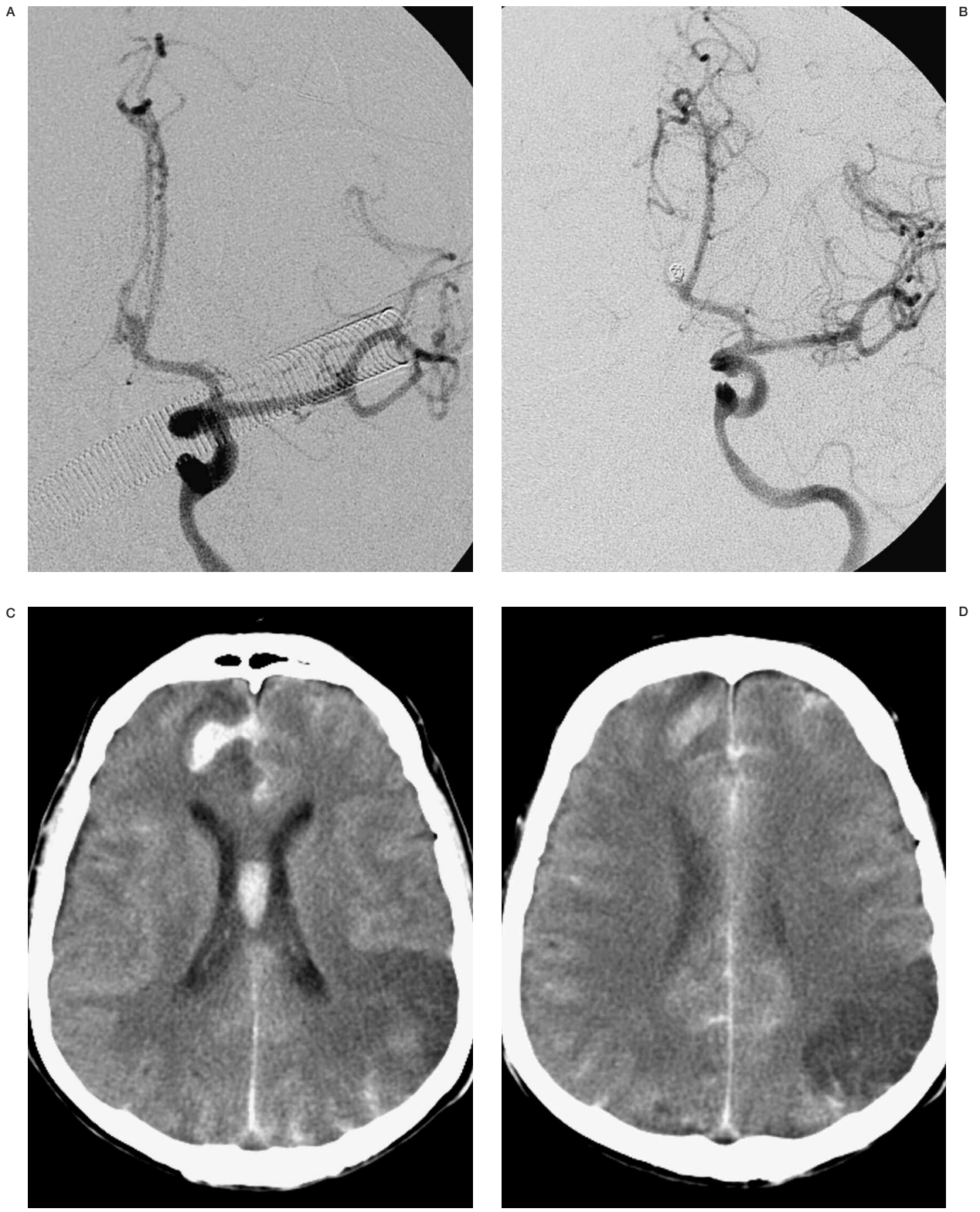

Figure 5 Digital angiography, arterial phase. A) Aneurysm of the left A1-A2 angle; B) imaging at the end of embolization shows sac occlusion; C,D) CT scan on the following day shows diffuse subarachnoid haemorrhage and an acute ischaemic lesion in the left fronto-temporo-parietal region housing the posterior branches of the middle cerebral artery: the lesion may not have been related to embolization, but caused by an arterial spasm.

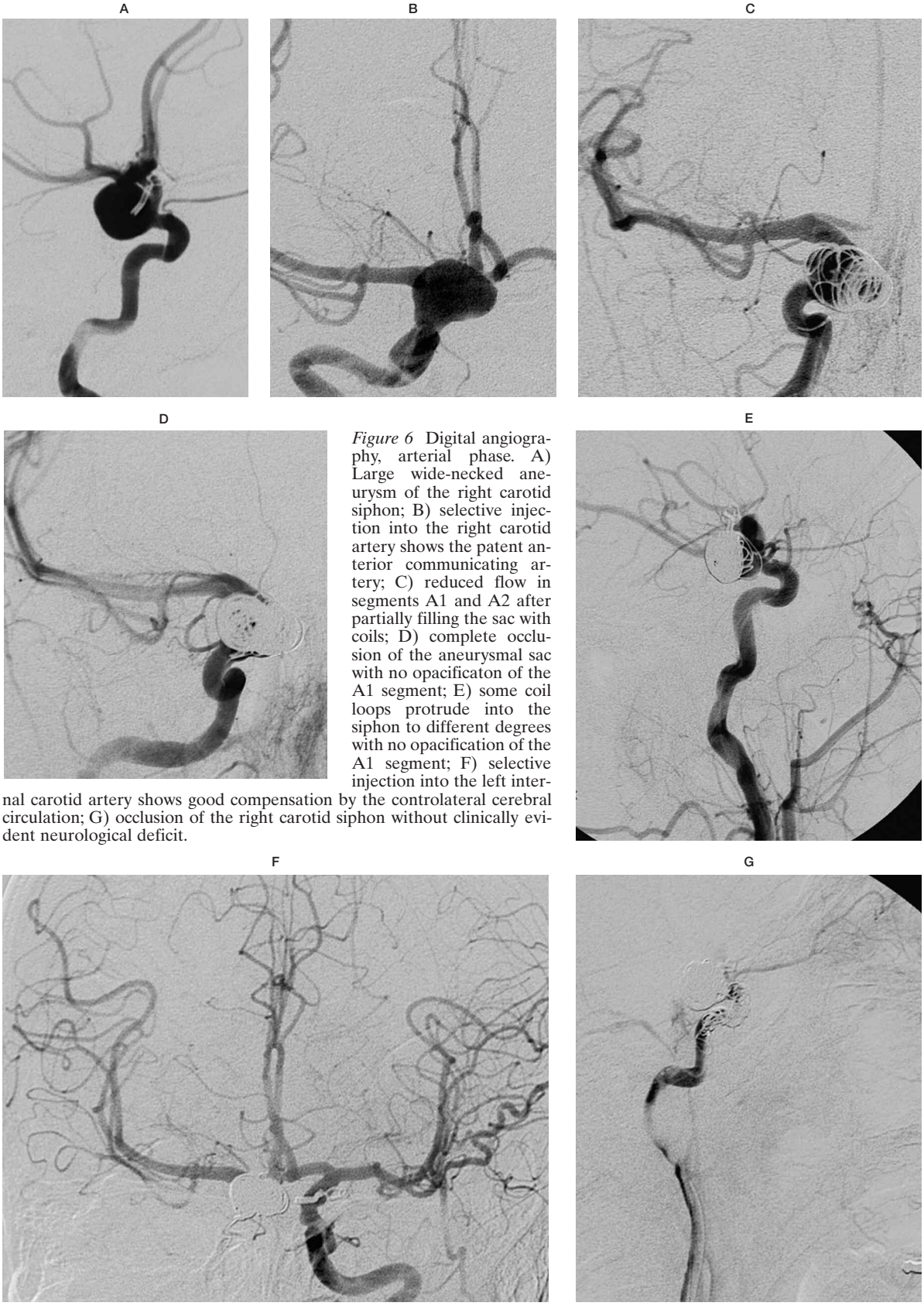

Figure 6 Digital angiography, arterial phase. A) Large wide-necked aneurysm of the right carotid siphon; B) selective injection into the right carotid artery shows the patent anterior communicating artery; C) reduced flow in segments A1 and A2 after partially filling the sac with coils; D) complete occlusion of the aneurysmal sac with no opacificaton of the A1 segment; E) some coil loops protrude into the siphon to different degrees with no opacification of the A1 segment; F) selective injection into the left internal carotid artery shows good compensation by the controlateral cerebral circulation; G) occlusion of the right carotid siphon without clinically evident neurological deficit.

Figure 7 Digital angiography, arterial phase. A) Large aneurysm of the right carotid siphon; B,C) the tortuosity of the internal carotid artery and siphon foil attempts to position and itracranial stent. In an attempt to retrieve the stent D) it migrates spontaneously into the tibial artery; E) imaging at the end of coil embolization shows occlusion of the sac.

also be kept in mind during endovascular embolization procedures.

The failure rate of aneurysm embolization, proportional to the main technical complication of coil migration into the vessel lumen in the case of wide-necked lesions, dropped sharply from five in 2000 and ten in 2001 to one in 2002 following the introduction of three-dimensional coils. These devices have a better shape memory and form a more solid basket to accomodate the coils even in the case of aneurysms with wide, albeit not very wide necks [30].

The insertion of intracranial metallic stents proved highly unsatisfactory. One stent was lost after migration into the popliteal artery, fortunately without clinical sequelae, whereas thrombosis occurred in a stent positioned in the basilar artery, causing one of the most severe clinical complications encountered. This means that half of the total number of intracranial stent placements during the three-year period resulted in severe complications. For this reason, we now use a different type of stent and small "intracranial" metallic stents are confined to cases with severe stenosis of the carotid arteries in the neck.

There has been a steady increase in the number of tumours treated prior to surgery since particles were replaced with acrylic glue which surgeons find more stable and complete. The number of embolization procedures rose from 12 in 2000 and 11 in 2001 to 19 in 2002 [8,12].

Conclusions

Endovascular embolization has to be classified as a high risk medical procedure, a risk not fully grasped by neuroradiologists or patients [7]. A hundred years of radiology have taught us that the x-ray unit is not an operating theatre and patients must "go out as they came in". It is now essential for colleagues and patients alike to be fully informed of all the risks and difficulties involved in interventional procedures. An ongoing review of cases will disclose the reasons for failure and complications, thereby improving technical procedures and materials to achieve ever better results.

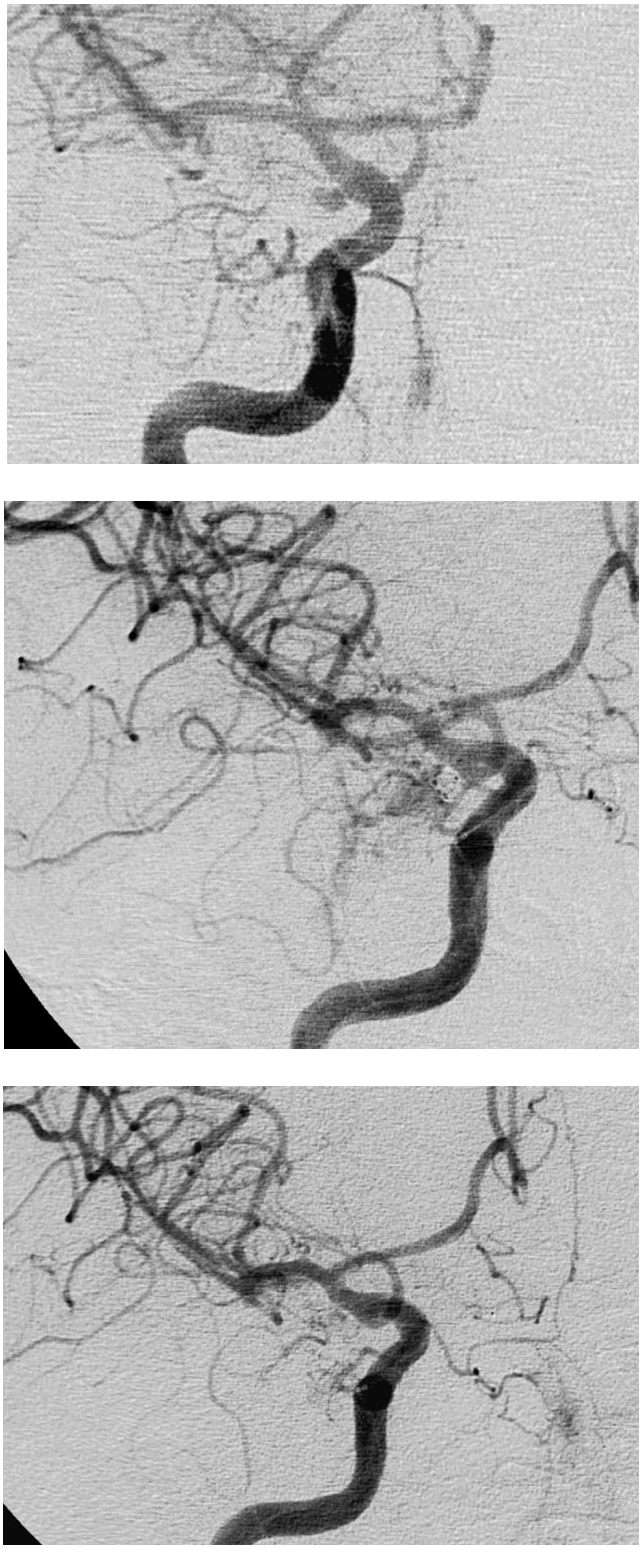

Figure 8 Digital angiography, arterial phase. A) Small aneurysm of the right siphon; B) slight leakage of contrast medium into the subarachnoid space adjacent to the sac after placement of the second coil; C) at the end of the procedure the sac appears occluded.

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